DELL EMC POWERMAX 8000 & VMAX ALL FLASH 950F
OVERVIEW FOR MAINFRAME ENVIRONMENTS

ABSTRACT

This white paper describes the features that are available for Dell EMC® PowerMax 8000 and VMAX™ 950F for IBM Z systems as well as the latest features available with Mainframe Enabler V8.3 for z/OS. Throughout this document, PowerMax refers to the PowerMax 8000 and VMAX refers to VMAX All Flash 950F.

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EXECUTIVE SUMMARY

Organizations around the globe need IT infrastructures that can deliver instant, continuous access to the massively increasing volumes of data associated with traditional online transaction, batch processing, and big data use cases such as data warehousing and data analytics. This must be accomplished with a continuous reduction in total cost of ownership (TCO), improvement in storage Service Level Agreements (SLAs) and mitigation of risk associated with storing the data. Many are contractually bound to SLAs that describe required levels of service, often with penalties associated with non-compliance. Organizations are trying to understand how the new generation of ‘systems of engagement’ applications, built around the world of social, mobile, cloud, and big data (collectively named the “3rd Platform” by IDC) can be leveraged on the mainframe (known as the 1st platform) which serves as the “system of record” for most large organizations. New threats to data availability and integrity are surfacing almost weekly and IT organizations must respond with state-of-the-art techniques to protect their data. Dell EMC has been helping enterprises solve mainframe storage problems for decades and is now redefining the traditional storage array, morphing it into a “Data Services platform” that will become the bridge between the 1st and 3rd platforms to modernize and deliver the next generation of Hybrid Cloud computing and storage with the ultimate in availability, data integrity, and TCO management.

Modern mainframe storage architectures require:

- Massive capacity scaling
- Massive performance scaling
- Flexibility to handle highly fluctuating workloads yet maintain consistent service levels, all the time
- Both physical and logical protection from threats to data integrity and availability
- A data protection infrastructure that can scale across an unlimited number of arrays, sysplexes, and physical locations
- Reduced costs through infrastructure hyper-convergence
- A usage model that is automated and almost totally hands off, unifying management with other platforms and further reducing TCO

The mainframe-enabled PowerMax 8000 and the VMAX All Flash 950F arrays are designed to meet and exceed these requirements through:

- Leveraging a scale out architecture up to 8 engines, 576 cores, 16TB cache and 256 physical host connections
- Leveraging the powerful Dynamic Virtual Matrix architecture in a single storage tier.
- The most advanced local and remote replication solutions in the industry
- A converged storage platform capable of running powerful storage and application workloads on PowerMax and VMAX including Mainframe, Open, IBM i
- An ease of use model that is unique in the high end storage arena

This paper explains how the PowerMax and VMAX arrays delivers these capabilities and more for mainframe environments.

AUDIENCE

This white paper is intended for Dell EMC customers and those evaluating Dell EMC storage for purchase.
INTRODUCTION

Dell EMC’s PowerMax and VMAX are incredibly well positioned to solve the CIO’s challenges of embracing a modernized, flash-centric data center while simultaneously trying to simplify, automate, and consolidate IT operations. PowerMax and VMAX aren’t just bigger, better, and faster (although they are!), Both are a flexible Data Services platform that specifically addresses the new requirements of the modern mainframe data center while continuing to deliver the reliability and availability our customers have relied on for years.

With PowerMAX and VMAX, the industry’s leading tier 1 array has evolved into a thin-provisioned hardware platform with a complete set of rich software data services including Data Protector for z systems (zDP), a revolutionary new data protection solution that enables rapid recovery from logical data corruption, be it from simple processing errors or malicious intent. Data services are delivered by a highly resilient, agile hardware platform that offers global cache, CPU (processing) flexibility, performance and high availability at scale to meet the most demanding storage requirements.

These arrays radically simplify management at scale by eliminating the need for storage administrators to answer the questions “how many disks of which type to allocate” and “where does my data need to be placed?” Tier 1 storage management can now be done in a matter of minutes, and doesn’t require extensively trained IT storage administrators.

The PowerMax 8000 differentiates itself as the first Dell EMC hardware platform with a storage back-end that uses Non-Volatile Memory Express (NVMe) for customer data. NVMe is a set of standards which define a PCI Express (PCIe) interface used to efficiently access storage devices based on Non-Volatile Memory (NVM) media, which includes today’s NAND-based flash along with future, higher-performing Storage Class Memory (SCM) media technologies such as 3D XPoint and Resistive RAM (ReRAM). The NVMe-based PowerMax was specifically created to fully unlock the bandwidth, IOPS, and latency performance benefits that NVM media offers to host based applications which are unattainable using the current generation all flash storage arrays.

By delivering these capabilities, PowerMax and VMAX improves overall staff productivity, giving them time to focus on the needs of the business, rather than management of the technology.

Dell EMC PowerMax 8000 and VMAX All Flash 950F arrays continue the mainframe legacy of all Symmetrix, DMX, and VMAX arrays that have come before it. They enable IT departments to consolidate, economize and reduce risk within their data center infrastructure while delivering mission-critical storage with scale, performance, availability, security and agility from Dell EMC that companies have relied on for years.
SYSTEM OVERVIEW: POWERMAX 8000 AND VMAX 950F

Figure 1 below hows the basic building block of both the PowerMax and VMAX array is the ‘engine’. An engine is a pair of physically separate director boards housed in the same enclosure. In order to enhance availability, each director board is physically independent, with its own Intel® processors, power feed and redundant hardware. The director board supports Intel Broadwell processors with 18 physical cores each (50% more than previous models). An eight engine PowerMax 8000 or VMAX 950F array employs 576 Intel processor cores. Since the operating systems of both arrays (PowerMaxOS and HYPERMAX OS) exploit the SMT2 feature of the Intel processors, in reality there are up to 1152 logical processor cores deployed in an eight engine array.

PowerMax and VMAX are built using a combination of ‘bricks’ (called V-Bricks in VMAX and PowerBricks in PowerMax) and ‘capacity packs’. Bricks are comprised of an engine and a capacity pack containing, at a minimum, 13TB of flash drive capacity. In engines configured for FICON /CKD only these are called zBricks (or zPowerbricks) and zCapacity Packs.

The PowerMax 8000 platform includes:
- 1 - 8 PowerBricks / zPowerBricks per system
- 2 x 18 core, 2.8 GHz, Intel Broadwell CPUs yielding 72 cores per PowerBrick
- 1 TB, 2 TB DDR4 cache per PowerBrick
- Up to 256 FE ports per system (OS and MF)
- Up to 4 PBe capacity per system (up to 1.7PBu if CKD only) of PCIe Gen3 NVMe storage in two racks
- Open systems and/or mainframe support
- 24 slot NVMe DAE using 2.5” form factor 1.92 TB, 3.84 TB, or 7.68 TB NVMe Drives
- Dual ported NVMe PCIe Gen3 (8 lane) backend I/O interface modules (4 per engine) delivering 8 GB/sec of bandwidth per module (32 GB/sec per engine) to the NVMe storage
- Powerful data reduction I/O modules which perform both inline hardware data compression and deduplication for FBA formatted disk only.

The VMAX 950F platform includes:
- 1 - 8 V-Bricks / zBricks per system
- 2 x 18 core, 2.8 GHz, Intel Broadwell CPUs yielding 72 cores per engine
- 1 TB, 2 TB DDR4 cache per engine
- Up to 256 FE ports per system (MF, 192 for OS)
- Up to 4 PBe capacity per system using SAS-2 all-flash storage
- Open Systems and/or mainframe support
- Two 4U Drive Array Enclosures (DAEs) that house up to 120 6 Gb/s SAS attached 2.5” TLC flash drives of 960GB, 1.92TB, 3.84TB, 7.68TB, or 15.36TB with a base storage capacity, of 13 TBu.
Dynamic Virtual Matrix/Infiniband Fabric

The Dynamic Virtual Matrix provides the Global Memory interface between directors with more than one engine. The Dynamic Virtual Matrix is composed of multiple elements, including Infiniband Host Channel Adapter (HCA) endpoints, Infiniband Interconnects (switches), and high-speed passive, active copper, and optical serial cables to provide a Virtual Matrix interconnect.

A fabric Application Specific Integrated Circuit (ASIC) switch resides within a special Management Interface Board Enclosure (MIBE), which is responsible for Virtual Matrix initialization and management. Each fabric port connects back to an Infiniband switch housed in the first system bay cabinet. The Infiniband switches are only present in multi-engine systems and are added with the addition of a second engine. Infiniband switches are installed in pairs and each director has a path to Fabric switch A and B. Fabric switches are supported by standby power supplies for vault activities to ensure all cache data gets vaulted.

PowerMax 8000 Drive Array Enclosures (DAE) and Drive Configurations

Each PowerBrick comes with two 24-slot, dual-ported, 2.5” PCIe NVMe DAEs (DAE24). These DAEs use redundant, hot-swappable Link Control Cards (LCCs) which provide PCIe I/O connectivity to the NVMe flash drives. Aside from redundant LCCs, the DAE24 features redundant power supplies with separate power feeds, providing N+1 power and cooling, resulting in an energy efficient consumption of 25 watts per drive slot. The DAE24 is 2U high and 19” deep.

PowerMax Drive Options and Universal Sparing

PowerMax 8000 supports 1.92 TB, 3.84 TB, and 7.68 TB NVMe flash drive capacities. All the drive sizes are 2.5” and feature a dual ported U.2 form factor PCIe interface. These drive capacities can be intermixed on the system. PowerMax uses universal sparing: systems with mixed drive configurations can use a single spare drive with the largest capacity size in the system. For example, if a system uses both 3.84 TB and 7.68 TB drives in the configuration, only one 7.68 TB drive needs to be configured as a spare, because it can replace either the 3.84 TB or 7.68 TB drives.

The Universal Spare can be also used in mixed systems with multiple storage resource pools (SRP). For example, if the mixed system uses 7.68 TB drives for the FBA SRP and 3.84 TB drives for the CKD SRP, the system will still only need a single 7.68 TB drive spare.

There are some rules for mixing drive capacities and universal sparing on PowerMax:

- There can be only two drive size types on the system and the drive sizes need to be one sequential drive size apart. For example, the system can have a mix of 1.92 TB and 3.84 TB drives, but not 1.92 TB and 7.68 TB sizes.
On mixed systems, drive mixing rules apply only with the individual SRPs. For example, the CKD SRP can have 1.92 TB and 3.84 TB drives, while the FBA SRP can have 3.84 TB and 7.68 TB drives. In this case, both SRPs would require a unique spare. The CKD SRP could use a single 3.84 TB spare, while the FBA SRP could use a single 7.68 TB spare. A single 7.68 TB drive could not be used as a universal spare for both the CKD and FBA SRPs in this case because it is beyond one drive size apart from the 1.92 TB drives in the CKD SRP.

**PowerMax Smart RAID**

PowerMax uses a new active/active RAID group accessing scheme called Smart RAID. This allows RAID groups to be shared across directors, giving each director active access to all drives on the PowerBrick or zPowerBrick.

![PowerMax Smart RAID Diagram](image)

The use of Smart RAID on PowerMax provides customers with performance benefits as both directors on an engine can drive I/O to all the flash drives. This creates balanced configurations in the system regardless of the number of RAID groups. Smart RAID also allows for increased flexibility and efficiency as customers can order PowerMax systems with a single RAID group allowing for a minimum of 9 drives per engine with RAID 5 (7+1) or RAID 6 (6+2 and 1 spare). This leaves more drive slots available for capacity upgrades in the future. When the system is scaled up, customers have more flexibility because flash capacity pack increments can be a single RAID group.

**PowerMax 8000 System Configurations**

PowerMax 8000 is the flagship of the PowerMax family and provides Dell EMC customers with unmatched scalability, performance, and IOPS density. It can consolidate disparate workloads on a mass scale as 8 PowerBricks can support over 10 million IOPS (8K RRH) and provide up to 4 PB of effective capacity in just two floor tiles of space.
The PowerMax 8000 is a highly configurable data storage array as it can support configurations from 1 to 8 PowerBricks within two standard Dell EMC Titan racks. Each rack can support up to four PowerBricks. PowerBricks 1 – 4 always occupy a single rack. PowerMax 8000 only requires a second rack when the PowerBrick count is greater than four.

The figure below shows a single rack PowerMax.

![Single and Dual PowerBrick Configurations](image)

**Figure 5** PowerMax 8000 single and dual PowerBrick configurations

The PowerMax 8000 uses redundant 16 port Dell X1018 Ethernet Switches for the internal management network. This network connects to every engine and to the two internal InfiniBand fabric switches. The InfiniBand switches are required when two or more PowerBricks are configured in the system. The redundant 18 port InfiniBand fabric switches connect to every director in the system.

DAE 3 is added with the second PowerBrick. As mentioned earlier in the document, DAE 2 is shared by PowerBrick 1 and PowerBrick 2. In DAE 2, drive Slots 1 – 14 are used by PowerBrick 1 while slots 15 – 24 are used by PowerBrick 2. A PowerMax 8000 configuration rule of thumb is that every even numbered PowerBrick shares a DAE with the previous odd-numbered PowerBrick.

**Note:** The PowerMax 8000 supports the use of third-party racking. The third-party rack must be a standard NEMA 19-inch rack and meet Dell EMC standards for power, cable access, and cooling. For more information about PowerMax 8000 third-party racking options please see the Dell EMC PowerMax Family Site Planning Guide.

The following diagram shows a three and four PowerBrick configuration for the PowerMax 8000:
Dual Rack PowerMax 8000 Configurations
PowerMax 8000 systems that have more than four engines require a second rack (system bay). PowerBricks are added to the second rack in the same manner and order as PowerBricks 1 – 4 are added in the first rack. The engines for the PowerBricks in the second rack are connected to the Dell X1018 Ethernet management switches. The PowerBrick engine directors in the second rack are cabled to the InfiniBand switches in the first rack also. No additional InfiniBand or Dell X1018 switches are required for the second rack.
The PowerMax 8000 supports rack 2 dispersion configurations of up to 82 feet (25 meters) from the fabric switches in rack 1. Dispersed configurations require optical connections between the InfiniBand switches in rack 1 and the PowerBrick engine directors in rack 2. Adjacent rack configurations can use Copper for connections between the PowerBrick engines in rack 2 and the InfiniBand switches in rack 1.

The following diagrams show the various PowerMax 8000 two-rack configurations:
VMAX All Flash 950F Drive Array Enclosures (DAE) and Drive Configurations

VMAX 950F systems provide an ultra-high density DAE supporting up to 120 2.5” drives each. Figure 7 shows the DAE.

DAEs can be added to systems in single increments if using RAID 1, RAID 5 (3+1), and RAID 6 (6+2). However, if a system contains RAID 5 (7+1) or RAID 6 (14+2), adding DAEs may only be possible in pairs. A VMAX engine is able to support up to 6 DAEs (720 x 2.5” drives).

When the system is configured at the factory, drives are distributed across engines in balanced configurations to provide the optimal performance in the array. When drives are added it is expected that they will also be added in a balanced manner.

Every DAE has 4 power zones and can thus continue to operate despite the loss of power to any one zone (which would require loss of two separate power supplies, also known as a double fault). If required, it is possible to configure RAID 6 (14+2) and RAID 5 (7+1) across 4 DAE so that only one member resides in any power zone.
Local RAID: Performance and Physical Configuration Benefits
VMAX arrays implement local RAID which requires all members of a RAID group to be associated with the same engine. This ensures local access and control over I/O for all RAID members and reduces the number of messages and Global Memory operations that need to be carried out for RAID operations, lowering I/O overhead and improving RAID performance.

Local RAID also eliminates the need for cross-bay (cross-frame) cabling in direct/daisy chain DAEs. This allows for the physical separation of a multiple frame VMAX system at the engine/bay level (in order to position the frames around any obstacles or across an aisle in the datacenter), making the VMAX systems the most flexible storage system in the industry.

6 Gb/s SAS back-end/drive infrastructure
All VMAX 950F models utilize 6 Gb/s SAS (Serial Attached SCSI) drives with a “back-end” configuration that provides improved performance over legacy architectures. SAS is a high-speed, extremely reliable protocol that uses the same low-level technology as Fibre Channel encoding. SAS topology is different from Fibre Channel as SAS uses a connectionless tree structure with unique paths to individual devices. Routing tables store these paths and help to route I/O to the required locations.

Dense Single Cabinet Configurations
All VMAX 950F arrays can be configured with a single engine per cabinet and up to 6 DAEs. Alternatively, and most commonly for mainframe configurations, a system can be configured to have 2 engines per system bay with 4 DAEs (up to 480 2.5” drives) to provide a much denser storage configuration, up to 4.42 PBe. A single bay can support 64 host ports and up to 4TB of cache in a single standard floor tile. Figure 8 shows the layout of the single engine and dense configuration.
Bay (rack) Dispersion

Both the VMAX 950F and PowerMax 8000 racks can be physically separated by up to 25 meters to avoid columns and other obstacles in the data center without a need to reserve empty floor tiles for future array growth. Any VMAX or PowerMax system bay can be placed anywhere in your data center as long as it is within 82 feet (25 meters) of the first system bay which houses the Infiniband Dynamic Virtual Matrix switches. Figure 9 shows a possible dispersion (separation) option for an 8-engine VMAX 950 with 2 adjacent system bays and 6 system bays dispersed at a distance of 25M each from system bay 1.

![Figure 11 VMAX and PowerMax Bay Dispersion](image)

HYPERMAX OS AND POWERMAXOS

The internal operating system that controls the array’s resources and data services is called HYPERMAX OS in the VMAX 950F and POWERMAX OS in the PowerMax 8000. These operating systems combine industry-leading high availability, I/O management, Quality of Service (QoS), data integrity validation, storage tiering, and data security with the first real-time, non-disruptive storage hypervisor that manages and protects embedded services. The hypervisor can be non-disruptively upgraded on all engines in the array.

These hypervisors reduce external hardware and networking requirements, deliver higher levels of availability, and dramatically lowers latency. HYPERMAX OS and PowerMaxOS run the 56Gb/sec Infiniband based Dynamic Virtual Matrix which provides redundant interconnectivity to all engines in the array leveraging the scale-out flexibility of cores, cache, and host interfaces.

HYPERMAX OS and PowerMaxOS provide:
• Virtual provisioning infrastructure with a capacity allocation granularity of a single track, the smallest in the industry
• The management of system resources to intelligently optimize performance across a wide range of I/O requirements and ensure system availability through advanced fault monitoring, detection, and correction capabilities
• Concurrent maintenance and serviceability features
• The foundation for specific software features available through Dell EMC’s disaster recovery, business continuity, and storage management software
• Functional services for VMAX and PowerMax arrays and for a large suite of Dell EMC storage application software
• Automated task prioritization, including basic system maintenance, I/O processing, and application processing

Embedded Hypervisor

HYPERMAX OS derived its name from the inclusion of a hypervisor which enables embedded data services to execute directly on the storage array delivering new levels of efficiency to enterprise workloads. PowerMaxOS also includes a hypervisor. This guest operating system environment is currently used to provide these services:

1. Monitoring and control of a single VMAX or PowerMax via a ‘tools’ guest hosting Solutions Enabler and Unisphere for array management and performance monitoring
2. The analytics components of Fully Automated Storage Tiering pattern recognition as well as host-provided hint translation services. This component is used by a number of internal technologies to determine the priority of a transaction.
3. Embedded NAS (eNAS) which provides flexible and secure multi-protocol file sharing (NFS, CIFS/SMB 3.0) as well as multiple file server identities (CIFS and NFS servers)

Virtual Provisioning

All VMAX 950F and PowerMax arrays arrive pre-configured from the factory with Virtual Provisioning Pools ready for use. VMAX and PowerMax pool all drives into a Storage Resource Pool (SRP) which provides physical storage for thin devices that are presented to hosts, and require no initial setup by the storage administrator, reducing the time to I/O and radically simplifying the management of the array. With the SRP, capacity is monitored at the SRP level and disk pools, RAID levels, and thin device (TDEV) binding to storage pools are no longer constructs the storage administrator needs to manage. All thin devices are ready for use upon creation and RAID is implemented under the covers in the SRP as part of the pre-configuration. The figure below shows the SRP components and the relationship to the storage group (SG) used for grouping thin devices to the host applications. Note there is a 1:1 relationship between disk groups and data pools. Each disk groups specifies a RAID protection and disk size forming the basis for each of the preconfigured thin pools. Every VMAX and PowerMax array comes from the factory with the configuration file (bin file) already created. This means best
practices for deployment - TDAT sizes, RAID protection, and data pools - will already be in place and no longer have to be created or managed by the storage administrator.

VMAX and PowerMax arrays support 3380 and 3390 CKD volumes using a single 56KB track size as the allocation unit for storage from SRPs for thin provisioned devices. When thin devices are created in a VMAX or PowerMax array they consume no space from the SRP until they are first written. Space reclamation is performed periodically via a Dell EMC z/OS based batch utility.

**Data at Rest Encryption (D@RE)**

Data in enterprise storage must be secure, both inside and outside of the VMAX or PowerMax. D@RE (Data at Rest Encryption) ensures that the potential exposure of sensitive data on discarded, misplaced, or stolen media is reduced or eliminated. D@RE provides hardware-based, on-array, back-end encryption for VMAX and PowerMax models running HYPERMAX OS and PowerMaxOS. Encryption within each individual disk drive (“back-end” encryption) protects your information from unauthorized access even when drives are removed from the system. D@RE provides encryption on the back end using modules that incorporate XTS-AES 256-bit data-at-rest encryption. These modules encrypt and decrypt data as it is being written to or read from a drive. All configured drives are encrypted, including spares. In addition, all array data is encrypted, including Symmetrix File System and Vault contents.

D@RE incorporates RSA® Embedded Key Manager for key management which provides a separate, unique DEK (Device Encryption Key) for all drives in the array including spare drives. D@RE keys are self-managed, so there is no need to replicate keys across volume snapshots or remote sites.

As long as the key used to encrypt the data is secured, encrypted data cannot be read. In addition to protecting against threats related to physical removal of media, this also means that media can readily be repurposed by destroying the encryption key used for securing the data previously stored on that media. Customers can now also leverage secure external key managers for data at rest encryption via the KMIP standard.

D@RE is compatible with all VMAX and PowerMax system features, allowing for encryption of any supported logical drive types or volume emulations and delivers powerful encryption without performance degradation or disruption to existing applications or infrastructure.

**Multi-Core Emulation: Processing Power Where it’s Needed Most**

VMAX and PowerMax arrays can be configured to allocate more CPU cores to handle host I/O, allocate more CPU cores to handle disk I/O, or allocate CPU cores evenly between front and back end operations. Pre-defined CPU core mappings allow specification of performance characteristics based on expected I/O profiles and usage of the system. Most, but not all, mainframe workloads require front-end centric configurations and are so configured in the factory.
This flexibility is made possible by Multi-Core emulation which improves the CPU and physical port utilization of HYPERMAX OS and PowerMaxOS, extending the proven VMAX and PowerMax architecture while improving overall performance. The figure below shows the default Multi-Core emulation in VMAX and PowerMax arrays. Cores are pooled for front end, back end, and for HYPERMAX OS and PowerMaxOS functions. Multiple CPU cores on the director will work on I/O from all of the ports. This helps ensure directors' ports are always balanced.

![Multi Core emulation](image)

**Vault to FLASH**

Vaulting is the process of saving Global Memory data to a reserved space within the VMAX and PowerMax during an offline event. Vault to FLASH provides vaulting of Global Memory data to internal flash I/O module(s). This feature provides the following advantages:

- Improved array performance due to larger Global Memory per director, capable of being saved within 5 minutes
- Physically, the arrays weigh less (fewer batteries are required to save data when a power interruption is detected)
- VMAX and PowerMax are easier to configure as there is no longer a requirement to reserve capacity on back-end drives for vault space
- A minimum drive count per engine is no longer required

**MANAGEMENT SOFTWARE**

**Mainframe Enabler**

Mainframe Enabler (MFE) is a suite of z/OS based products for managing your VMAX or PowerMax in a z/OS environment. MFE commands can be used to monitor device configuration and status and perform control operations on devices and data objects within your Dell EMC VMAX or PowerMax storage environment.

Mainframe Enabler 8.0 or above is required for VMAX arrays running the HYPERMAX OS 5977 releases. Mainframe Enabler 8.3 or above is required for VMAX arrays running the HyperMax OS and PowerMaxOS 5978 releases to exploit new functionality, but MFE 8.2 has toleration support for arrays running HyperMax OS and PowerMax OS 5987. MFE 8.3 is also downward compatible with older VMAX and Symmetrix arrays.

**GDDR – Geographically Dispersed Disaster Restart**
Geographically Dispersed Disaster Restart (GDDR) is Dell EMC's automated continuity product for both primary (disk) and backup (tape) storage. It provides automated recovery from all manner of disaster and also provides unplanned swap capability. GDDR monitors the environment and provides alerts to potential problems, and automates their resolution. GDDR was the first in the industry to provide 3-site and 4-site solutions. GDDR can automate both mainframe and open systems environments together, and synchronize recovery of data across platforms. GDDR has been enhanced to support VMAX All Flash 950 and PowerMax 8000. Version 5.0 includes support for the new TimeFinder SnapVX local replication function, described below.

**Unisphere**

Unisphere for PowerMax is an HTML5 based management interface that enables customers to easily provision, manage, and monitor VMAX and PowerMax environments. Unisphere for PowerMax has been enhanced to support the new capabilities of the VMAX All Flash 950 and PowerMax.

With HYPERMAX OS and PowerMaxOS, it is possible to run Unisphere as a Guest Operating system directly within the native hypervisor, eliminating the need for an external management host, and associated fibre channel adapters to control and manage the VMAX or PowerMax array in a FICON attached environment. The Embedded Management option is defaulted when ordering the VMAX 950 or PowerMax system as CPU and memory requirements must be sized appropriately. Please see the Unisphere for PowerMax Documentation available at [https://support.emc.com](https://support.emc.com) for more information.

Unisphere offers simple “big-button” navigation and streamlines operations to simplify and reduce the time required to manage VMAX or PowerMax; it also simplifies storage management under a common framework.

Unisphere for PowerMax contains a number of task-oriented dashboards to make monitoring and configuring VMAX and PowerMax systems intuitive and easy. As an example, the Storage Group Dashboard displays information about application storage groups and whether or not they are meeting their SLO requirements. Administrators can quickly navigate

**TimeFinder SnapVX**

Dell EMC TimeFinder® software delivers point-in-time copies of volumes that can be used for backups, testing, data recovery, database system cloning, data warehouse refreshes, or any other process that requires parallel access to production data.

HYPERMAX OS 5977 for VMAX introduced TimeFinder SnapVX, which combines the best parts of the previous TimeFinder offerings with new ease-of-use features, increased scalability and significantly improved space efficiency.

In arrays running HYPERMAX OS or PowerMaxOS, TimeFinder SnapVX lets you non-disruptively create point-in-time copies (snapshots) of critical data at the volume level. SnapVX creates snapshots by storing pre-update images of tracks (snapshot deltas) directly in the SRP of the source device. These “point in time” snapshots only consume space when source tracks are updated. Tracks that are not updated share allocations across many snapshots, enabling the creation of many point in time copies of a volume without consuming additional space. SnapVX is also a “targetless snapshot” design, meaning a target volume is not required to obtain a point in time copy of a volume. In other words, the capture of a “point in time” has been separated from its use. Therefore, with SnapVX, you do not need to specify a target device and source/target pairs when you create a snapshot. If there is ever a need for the application to use the point-in-time data, you create links from the snapshot to one or more target devices. If there are multiple snapshots and the application needs to find a particular point-in-time copy for host access, you can link and re-link until the correct snapshot is located.

SnapVX for CKD volumes supports TimeFinder/Clone, TimeFinder/Snap (virtual devices), and TimeFinder/Mirror via emulations that transparently convert these legacy TimeFinder commands to SnapVX commands. You can still run jobs that use TimeFinder/Clone, TimeFinder/Snap, and TimeFinder/Mirror commands, but the underlying mechanism within HYPERMAX OS and PowerMax OS is SnapVX.

SnapVX supports up to 256 snapshots per source device (including any emulation mode snapshots). Legacy session limits still apply to the emulations of prior TimeFinder offerings. SnapVX and legacy TimeFinder
operations, as well as FlashCopy emulation, can only coexist on source volumes. Intermixing these technologies across source and target volumes is not supported at this time.

![Figure 14 TimeFinder SnapVX Snapshots](image)

You can set snapshots to automatically terminate after a specified number of days or at a specified date and time. Figure 3 shows multiple snapshots of a production volume with a Time to Live (TTL) of one day. SnapVX will only terminate the snapshot if it does not have any links to target volumes. If it does have links, SnapVX will terminate the snapshot when the last link has been unlinked. Writes to a linked target device will only be applied to the linked target and will not change the point in time of the snapshot itself. Snaps can be deleted in any order without affecting their sequencing.

**zDP™ – Data Protector for z Systems**

Much of the focus on data protection in the last twenty years has been on recovery from loss of a data center due to unplanned outages or disasters. The emphasis has been on providing copies of data at alternate sites and on ensuring that data integrity of the copies is preserved. **Availability with data integrity** has been the goal.

In recent years there has been an alarming number of examples of data corruption due to processing errors or malicious actors that result not in a loss of data availability, but a loss of data integrity in the production environment. All the storage-based replication technology deployed to protect against loss of data since the invention of data replication, provides no protection at all against data corruption, and in fact dutifully replicates corrupted data to all recovery sites with impressive speed and accuracy!

With data corruption risk taking on new and more dangerous forms beyond processing errors that, at best, introduce errant data to the more serious willful hacking and destruction of data, the responsibility of CIOs has expanded beyond rapid recovery from data center loss to rapid recovery from loss of data integrity.

Data Protector for z Systems (zDP) is designed to address the problem of large scale recovery from logical corruption. zDP is an Dell EMC industry exclusive z/OS-based application that utilizes SnapVX snapshots to enable rapid recovery from logical data corruption. zDP achieves this by providing multiple, frequent, and consistent point-in-time copies of data in an automated fashion across multiple volumes from which an application level recovery can be conducted. By providing easy access to multiple different point-in-time copies of data (with a granularity of minutes), precise remediation of logical data corruption can be performed using storage or application-based recovery procedures. zDP provides the following benefits:

- Faster recovery times as less data must be processed due to the granularity of the available point in time data copies
- Cross application data consistency for recovery data
- Minimal data loss compared to the previous method of restoring data from daily or weekly backups.
This is especially important for non-DBMS data, which does not have the granular recovery options provided by log files and image copies associated with database management systems.

Prior to zDP, the only way to recover from logical data corruption was an offline copy, either a BCV (Business Continuance Volume), sometimes known as a “Gold Copy” or a backup made to offline physical or virtual tape. Even in the best datacenters practicing the latest data protection procedures, often only one offline copy of the “state of the business” was being made per day. Considering that 144 Snapshots can be taken in a 24 hour period (at 10 minute intervals) with zDP as compared to a single BCV or offline tape backup, zDP gives you 144x the granularity to recover from a situation that could have otherwise been detrimental or fatal to your business.

**Enhanced SRDF**

The Symmetrix Remote Data Facility (SRDF) family of software is the gold standard for remote replication in mission critical environments. Built for the industry-leading high-end VMAX and PowerMax hardware architecture, the SRDF family of solutions has been trusted for disaster recovery and business continuity for more than two decades. Asynchronous SRDF (SRDF/A) enables remote data services to provide 6 9s of data availability (31.5 seconds of system downtime a year) and 24x7xForever operation. Synchronous SRDF (SRDF/S) can achieve 7 9s of availability (3.2 seconds of downtime a year). The SRDF family offers unmatched deployment flexibility and massive scalability to deliver a wide range of distance replication capabilities.

Another key change is an enhancement to the DSE (Delta Set Extension) feature which is designed to increase availability in SRDF/A environments. There is no longer a need to configure a separate pool in the array and there is no need for a DSE pool to exist in the remote (R2) array. Instead, the SRP will have a maximum DSE capacity associated with it (specified in GBs). DSE capacity is specified when the array is configured, resulting in a less complex configuration for the storage administrator to manage.

SRDF/A has also been improved to provide better resiliency and shorter and more predictable Recovery Point Objectives (RPOs) when operating under stress. This is done through an enhancement called Multi-cycle Mode (MCM) which allows more than two delta sets to exist on the source array. MCM has the benefit of always cycle switching based on the user set cycle time, so the cycles are now predictable and much smaller when applied to the secondary side. This eliminates the need for DSE on the secondary side.

SRDF/S has also been enhanced to provide increased performance of devices through reductions in replication processing overhead.

In addition, since all directors are capable of supporting a variable number of ports (up to 16 ports for every director configured with emulation for SRDF) the number of SRDF groups supported on an individual SRDF director (RA) has increased from 64 to 250, which is also the total number of SRDF groups allowed per array.

All VMAX and PowerMax array models are also capable of supporting enhanced hardware compression for bandwidth optimization on both IP and fibre links.

**16 Gb/s FICON and zHPF support**

The VMAX 950F and PowerMax support 16 Gb/s FICON. Each FICON channel adapter card (SLIC) within the array consists of a 4 port 16 Gb/s I/O module based on the industry-standard QLogic chip set that auto-negotiates with the host to support 4, 8, and 16 Gb/s link speeds. It is possible to configure up to 32 16 Gb/s FICON ports for each VMAX engine. Single Mode (SM) and Multi-Mode (MM) support is available and selectable at the time of ordering.

VMAX and PowerMax are 100% zHPF compatible. This includes:

- List Prefetch and Bi-Directional support. These features enable a single I/O to efficiently access discontiguous extents on a volume. This results in improved performance; for example, in DB2 when accessing indexes with poor cluster ratios (disorganized index scans).
- Format Write commands. This capability improves performance of utilities, such as DB2 load, reorg, index rebuilds and restores by enabling channel programs employing format writes to deliver large amounts of data in a single I/O.
- Exploitation of zHPF by the BSAM, QSAM, and BPAM access methods. In addition VMAX offers support for the following FICON enhancements announced with the IBM z13:
- Forward Error Correction (FEC) support for 16Gb/s FICON. This feature improves control over transmission errors on noisy fibre links and allows FICON to operate at higher speed over longer distances
- FICON Dynamic Routing (FIDR) which allows FICON to use dynamic routing policies for Inter-Switch Links (ISL) in the SAN
- Read Diagnostic Parameters to enable SAN management products to display diagnostic data for 16Gb/s links.
- zHPF Extended Distance II FICON which allows large write operations (> 64 KB) at distances up to 100 km to be executed in a single round trip, providing up to 50% I/O service time improvement and benefitting GDPS HyperSwap configurations

**IBM Z Compatibility**

Dell EMC ensures feature compatibility with comparable IBM offerings largely through a comprehensive technology licensing agreement with IBM, coupled with extensive feature testing.

As IBM adds new functionality to mainframe environments, Dell EMC continues to provide best-of-breed capabilities and compatibility. Like the VMAX3 arrays, the latest VMAX and PowerMax arrays provide compatibility with either IBM 2105 or 2107 control unit features when configured to all IBM Z operating environments (z/OS, z/VM, Linux on z, z/VSE, and z/TPF).

Mainframe compatibility for Dell EMC products is assured through the continued financial investment in key mainframe technology licenses with IBM spanning many relevant features and functions. These technology licenses are multi-year renewable contracts that allow Dell EMC to undertake a more timely and comprehensive approach in implementing the various features. Further, Dell EMC continues to invest in mainframe personnel and materials to ensure delivery of all licensed features and functions.

In addition to unique Dell EMC replication technology, Dell EMC offers several storage replication capabilities that are compatible with those offered on IBM storage arrays, including Compatible Native Flash (IBM FlashCopy) for internal point-in-time copies and Compatible Peer (IBM PPRC) for remote replication. Note that Compatible Peer is only supported between VMAX and PowerMax arrays. PPRC architecture does not support intermixing of vendors between arrays in a PPRC relationship, although multiple vendors’ PPRC pairs can coexist in a single environment. The table below lists the IBM features for which VMAX and PowerMax arrays provide compatibility:

<table>
<thead>
<tr>
<th>Technology</th>
<th>Features Supported</th>
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<tbody>
<tr>
<td>IBM Replication</td>
<td>- Metro Mirror (formerly PPRC)</td>
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<td></td>
<td>- Global Copy (formerly PPRC-XD)</td>
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<td></td>
<td>- GDPS/PPRC, GPDS/HM (including Enhanced Conditional FREEZE and Non-Disruptive State Save)</td>
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<td></td>
<td>- FlashCopy V1 and V2 (including Remote Pair Flashcopy and Multi-Incremental Flashcopy)</td>
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<td>- HyperSwap (Including Soft Fence)</td>
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<tr>
<td>IBM Channel Compatibility</td>
<td>- Parallel Access Volume (PAV)</td>
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<td>- Dynamic Parallel Access Volume (DPAV)</td>
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<td></td>
<td>- HyperPAV, SuperPAV</td>
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<td></td>
<td>- Multiple Allegiance (MA)</td>
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<td></td>
<td>- Modified Indirect Data Address Word (MIDAW)</td>
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<td>- SPID Fence</td>
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<td></td>
<td>- Extended Address Volume (EAV) – 1 TB</td>
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<td></td>
<td>- Priority I/O Queuing</td>
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</table>
CONCLUSION

VMAX and PowerMax offer a complete set of rich software data services including a revolutionary new continuous data protection solution for mainframe users: zDP. For both offerings, data services are delivered by a highly resilient, agile hardware platform that offers global cache, CPU flexibility, performance and the most FICON ports of any array in the industry to satisfy the most demanding storage infrastructure needs, whether converged (both mainframe and non-mainframe workloads running within the same VMAX 950F or PowerMax) or not.

These arrays are designed and built for management simplicity, extreme performance, hyper-consolidation and massive scalability in a dense footprint. Dell EMC introduced the storage industry’s first Dynamic Virtual Matrix and brought data services closer to the storage they access, eliminating the need to proliferate functionally-limited “data appliances” in the data center. The VMAX and PowerMax Data Services Platform enable flexible storage infrastructure decisions to be made that are not bound by what is capable within an appliance’s “frame.” This approach provides hyper consolidation, excellent Total Cost of Ownership (TCO), simple and agile management, while exceeding customers’ current and future needs for mainframe storage.

To learn more about how Dell EMC products, services, and solutions can help solve your business and IT challenges, contact your local representative or authorized reseller, visit www.emc.com, or explore and compare products in the Dell EMC Store.
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